CHANGING WATERSCAPES: The Dichotomy of Development and Water Management Surrounding the East Calcutta Wetlands since the British-colonial Era

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Abstract: The deltaic region of Bengal is known for its riverine networks and fertile soil. The capital of former British-India, Calcutta, was a swampy region with small canals connecting the land with the river Hooghly in the west and to the saltwater lakes in the east, now known as the East Calcutta Wetlands (ECW). The eastern canals carry the city's wastewater to the ECW for treatment using sewage-fed fisheries and farmlands and then released it into the Bay of Bengal via the Kulti River. In the early British colonial period, the salt lakes were depicted as hindrance to the health and well-being of the city's inhabitants because of high mortality in the region, presumably caused by miasmic diseases. Part of these marshes, the ECW now acts as a giant sink for this dense post-colonial urban settlement, helping to drain the land, providing food and employment, and saving costs for artificial wastewater treatment plant. This hydrologic system is now at risk due to encroachment from real-estate development and pollution in the adjoining canals, posing an immense threat to this critical human-water relationship. In this paper, we examine the dichotomy of urban development and water management since the colonial era to assess the temporal nature of the human-water negotiations behind the changing waterscapes.

Keywords: Colonial, wetlands, water, urban, Calcutta, human-water relationship

INTRODUCTION

The present city of Calcutta, India, was once a marshland protected by a levee from the River Hooghly. The land gradually sloped down from this levee in the west towards the saltwater lakes in the east, now known as the East Calcutta Wetlands[1] (ECW), recognized by the Ramsar Convention in 2002 as one of international importance (Ramsar 2002). Calcutta, being relatively flat (Richards 1914) and swampy, has been difficult to "tame" by the British in the colonial era. Institutional reports[2] on improving sanitation in the city spoke of the harrowing conditions created in the town due to poor drainage, flooding, and consequent health issues, especially from water-borne diseases. Natural canals weaving through this landscape were studied, experimented on[3], and modified to facilitate drainage and navigation in the region, addressing tidal fluctuations and problems with excessive siltation (Apjohn 1895). The canals in Calcutta now carry the city's wastewater to the ECW, where it is treated using fisheries and agricultural lands, saving the expenses of artificial wastewater treatment and providing local employment opportunities (Ghosh and Sen 1987). This unique system is under threat of encroachment and pollution from domestic and industrial sources, which have brought doubt over the water management strategies of this city of five million.

In this research, we examine a historical conflict between urban development and waterscapes in the Calcutta region, since the early days of the British colonial era. After scrutinizing British water management practices as the West's ways of countering the East's waters, we discuss the water woes of this city in colonial and post-colonial periods. This paper serves as an exploration of human-water negotiations that have historically prioritized urban development over sustainable management of water resources. Supported by findings from ethnographic fieldwork, we establish the problems currently being faced by the city's waterscape and identify present actions and consequences as a legacy of colonial water management, through a study of archival reports, journals, and planning documents.

1. URBAN DEVELOPMENT IN CALCUTTA

1.1. BEFORE BRITISH COLONIALISM IN CALCUTTA

Europeans had long been aware of the rich prospects that trade with the Indian subcontinent would bring into the Ganga-Brahmaputra deltaic region of Bengal, especially with goods like spices, textiles, and saltpeter (Cotton 1907). This attracted the Europeans–Portuguese, French, Dutch and finally, the British, to this land (Nair 1986). Riparian corridors of trade and transportation were crucial for this deltaic mercantile port-city and by connection, its hinterlands (Tan 2007). Trade, therefore, was serious business at the estuarine lowlands of Bengal, spread along the length of the River

Hooghly. To take advantage of Portuguese maritime trade, weavers settled across the river in a town called Sutanuti (Datta 2012, 12). Owing to the marshy nature of this landscape, the villages of Sutanuti, Kalikata, and Gobindapur never undertook conscious town planning endeavors, until the British excavated canals to drain the place and built roads for transit.

1.2. THE EARLY COLONIAL PERIOD IN CALCUTTA

The city of Calcutta started to gain importance as a trading post for the British after they defeated the Nawab of Bengal in the Battle of Plassey in 1757 and developed the land around Fort William. With already existing Indian settlements in the north of Fort William, the British administrators decided to expand their settlements to the east and the south of the central business district (Hornsby 1997). The southern part of the city was more pleasant owing to the cool prevailing winds from the Bay of Bengal. The expansion of Calcutta, however, highlighted racial, ethnic, and economic divisions in land use. Most port cities in India had an area where local inhabitants settled, known as the Black town and a European enclave known as the White Town (S. Chattopadhyay 2000). Calcutta, however, showed a third category of town known as the Grey town, which housed foreign populations like the Portuguese, Armenians, Greeks, and Jews (Hornsby 1997). The formation of white, black, and grey towns inside Calcutta developed spatial identities that remain present today.

In the earliest days of the East India Company, the city of Calcutta lacked any infrastructure deemed suitable to British India's first capital (Datta 2012). One of the first measures by the British, therefore, was to make Calcutta suitable for development by taming its marshy land and jungles. According to Chaudhuri (1990), there was no mention of an existing network of roads in Calcutta before the British arrived. Thoroughfares did not reflect any planned layout and did not have any name; they were generally referred to by people as "the road to the east", or "the road towards the river". In 1766, J. Fortnam, a Civil Architect for the British Administration, proposed new roads, buildings, and watercourses for Calcutta. His proposal mentioned two watercourses in Shambazar Road, two watercourses in Monickchurn Road, one watercourse in Chitpur Road, and one watercourse in the Chowringhee Road, for 125 rupees each. Besides, he also proposed the construction of twenty eight small bridges and watercourses in and around Calcutta for a sum of 3000 rupees. In 1749, the government ordered drains "to be surveyed to make the settlement sweet and wholesome" (Sen 2000). A network of planned roads can be seen in a map (figure 1) developed by A. Upjohn from the survey in 1792-93, published in 1794 (Chaudhuri 1990; Kundu and Nag 1990). Since then, the Lottery Committee and the Fever Hospital Committee continued developing the city of Calcutta by building roads, sewers, and canals for drainage. By the end of the nineteenth century, plague-stricken Calcutta needed a strategic intervention to improve the conditions of the city, especially of sanitation and transit systems (Richards 1914).

1.3. IMPROVEMENT AS A STRATEGY FOR URBAN DEVELOPMENT

The Calcutta Improvement Act of 1911 called for various improvement measures to be undertaken by the Calcutta Improvement Trust (CIT). Edwin Percy Richards, a British engineer examined the trust's work and wrote the *Report on the Condition, Improvement and Town Planning of the City of Calcutta and Contiguous Areas* (1914). It had been recognized as "the first systematic attempt to translate European planning ideas into a colonial context" (Home 2016). It poured insight into Calcutta's critical issues and its future growth, such as unhygienic conditions in slums, the need for transit systems to connect areas within the city and to its suburbs, and poor drainage, which remained relevant to this day. Inspired by the Glasgow Improvement Model, similar plans were developed for other Indian colonial port cities like Madras, Bombay, and Singapore (Datta 2012).

The *improvement* plans proposed by the CIT broadly addressed two issues: transit and sanitation. These improvement measures, popularized as necessary changes on the urban landscape for its own good, were as detrimental to the urban poor then as the developmental plans are now. To implement these changes, the social identity of the people was questioned, festivals and cultural gatherings were prohibited; housing for the poor was neglected. Richards had expressed his discontent regarding the poor capacity of the city's mass transit system (Richards 1914), noting that this would amount to a larger problem in the future.

"Improvement" plans further contributed to growing economic inequity and socio-spatial segregation, adding to the existing social turmoil. The use of urban public spaces was strictly limited to the Europeans and the Indian elites, who were unsure whether to prioritize equality over improved luxurious facilities in the city (Datta 2012). An article in the *Times of India*, a popular newspaper, spoke of the "urban improvement" in Calcutta as a movement that had placed Calcutta on the maps. While mentioning that the urban poor had been forcibly removed from their dwellings as a measure of improvement, the article went on to say that "the [Calcutta Improvement] Trust is entitled to gratitude for the success with which it

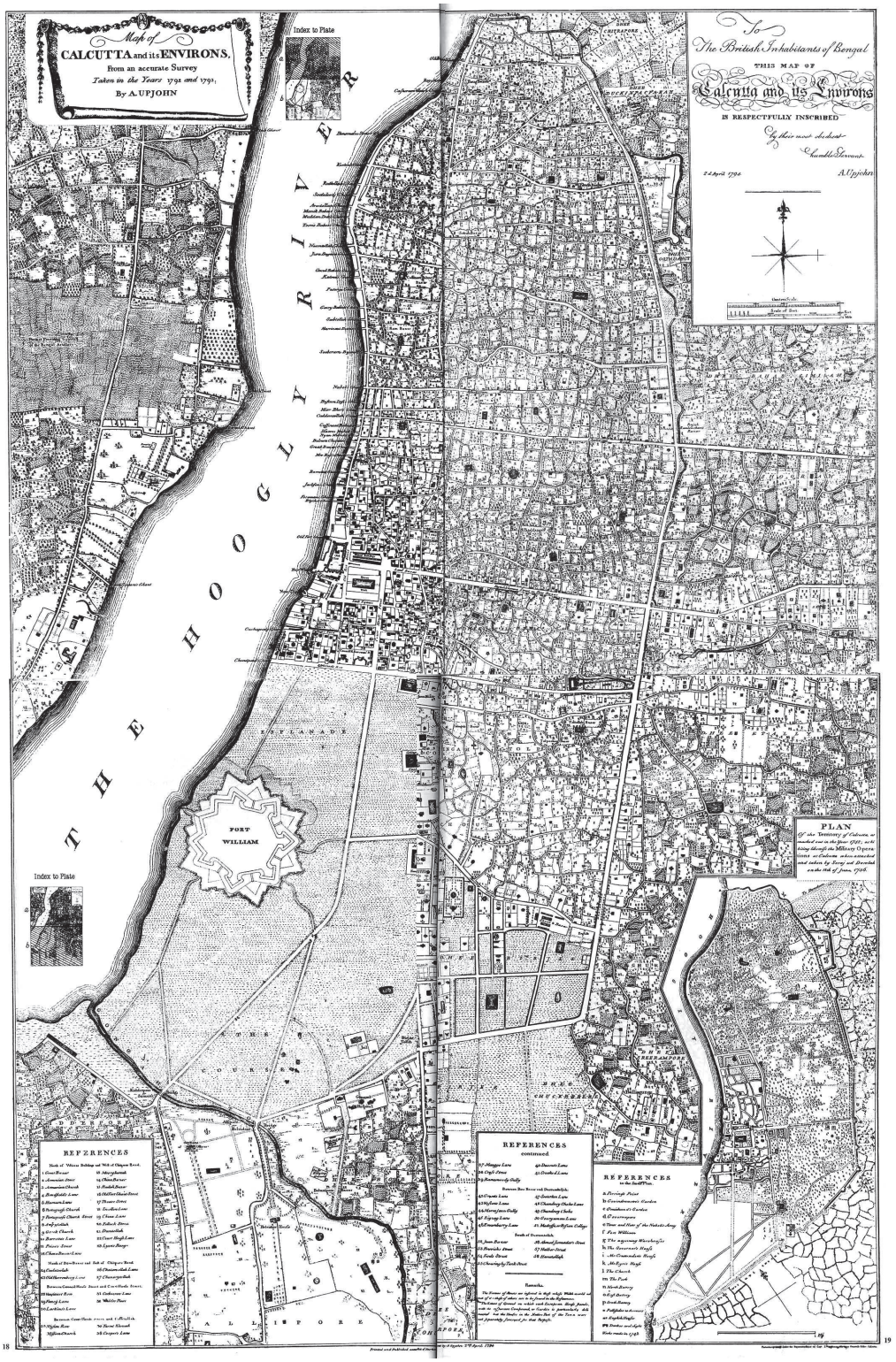

Figure 1: 1792 Map by Upjohn showing Fort William and roads of Calcutta. (Kundu and Nag 1990, 16-19)

has added to the amenities as well as the beauty of the premier city of India" (Times of India 1929). The article boasted an overflow of expenses towards improvement measures, but failed to reveal the increase in taxes and revenue that were directed towards providing additional funding for the Trust (Times of India 1929; Bompas 1927). Along with roads and public parks, the late nineteenth century also saw considerable development of canals for drainage, navigation, and irrigation. Canals were experimented on to tackle silt deposition and steady flow for navigation (Apjohn 1895). However, beyond urban development, water emerged as an instrument for socio-political change (Bakker 2012).

2. THE WEST'S WAY OF MANAGING THE EAST'S WATERS

The practice of finding the sacrificial lamb in waterscapes that gained momentum in the post-colonial era had been fueled by two centuries of imposition of western ways to manage water in the East. Demanding a higher water flow for increased productivity, the British uprooted traditional water management in rural India, and employed perennial irrigation through canals in the Punjab area (Agnihotri 1996). Gilmartin (1994) argued that control of irrigation was reflected upon as the hinge between the power of local community and that of the state. He explained how, in the 1850s, the British abolished the *chher* labor system in the Sind region, that employed unpaid local villages to clear off the silt in irrigation canals for "effective state management of canals" (Gilmartin 1994, 1134). Similar to management of other natural resources, including forests and farmlands, British intervention in water-management reflected "a distinct hydraulic paradigm", which D'Souza has addressed under the broader theme of "colonial hydrology" (2006, 621). He argued that the colonizers have historically imposed the western way of managing water by "fundamentally realigning land and water in new sets of social, political and ecological relationships." (D'Souza 2006, 625).

Colonial decisions on water endowment, much like the rest of their natural resource management approaches, predominantly saw the Indian subcontinent as a "seemingly immeasurable extent of natural" (Whitcombe 1972). To ensure the "productive control of natural resources," the British took to Imperial Science (Gilmartin 1994) and engineered solutions, where traditional Indian ways of water management were quickly shifted to the backseat, stamped "native" and "unscientific" (Agnihotri 1996, 39). What has been termed by D'Souza (2006) as "colonial hydrology", a grand scenario of shifting relationships between people and water was justified by the British administrators as "improving" upon the local knowledge. Colonial irrigation systems in the canals of Punjab led to adverse ecological conditions such as waterlogging and salinization as well as impacted the community (Agnihotri 1996, 37). Elizabeth Whitcombe's *Agrarian Conditions in Northern India* (1972) adds to the colonizers' impact on instruments of traditional water management including wells. In contrast, Ian Stone's monograph titled *Canal Irrigation in British India* (2002) argues that the British interventions in water management were, in fact, a crucial step towards the adaptation of new technologies by the peasants to maximize production, implemented with a view of economic dynamism.

3. WATER WOES IN CALCUTTA

3.1. CANALS

In the early settlements of Calcutta, not much attention was paid to the building of roads or drains by the Indians. Early roads were known to have shallow channels flanking the roads to take care of drainage, especially during the monsoon seasons. Poor drainage and sanitation increased the risks of water-borne diseases, making the region unsuitable for healthy living (Sen 2000). The roads carried dead bodies of animals, as well as human and cattle sewage in open drains which opened into the River Hooghly. However, these roads and the adjacent canals were identified by the British as unhygienic, and therefore, the land adjacent to this region was not suitable for habitation (Chaudhuri 1990). This laid the ground for the revival of the roads and drainage networks, which were guided by reasons of health and a sense of security.

The Maratha Ditch, which essentially separated the British settlements from the rest of the city (Sreemani 1998), was excavated in the 1740s from an existing canal presently known as the Circular Canal. The Circular Canal continued to the southern part of the city. However, this canal was initially excavated to keep the Maratha rulers away (Richards 1914) and was later critical in shaping the outer periphery of Calcutta (Sreemani 1998). The Calcutta port is situated in the southern part of the city, which is not highly silted and therefore easily accessible for transportation and shipping. The port is close to another existing canal known as the *Adi Ganga*, which was excavated by a Major William Tolly of the British East India Company in 1775 and opened to the public in 1777 (Bhattacharjee 2014). The *Adi Ganga* was leased to Major Tolly for 12 years for collecting revenue on the goods transported (Biswas 2001), and later came to be known as Tolly Nullah.[4]

Besides navigation, these canals also facilitated other urban systems like drainage and sanitation.

The need for a comprehensive sewer network was evident in both Mr. Clark's Drainage Scheme (1855) and the Cowie Report on draining the city of Calcutta (1857). However, it was debated whether the construction of a vast network would be disruptive to the residents' way of life. Therefore, it was decided that the network of sewers would be used as a guide for building new roads (Beverley and Lidderdale 1885). This would not only allow the engineers to properly drain the city but would also add to the cost of disruptions caused to the residents.

The British development of Calcutta induced the growth of many industries in the outskirts of the city. This included the development of leather industries in the Entali area.(Chaudhuri 1990). Presently, small-scale industries and informal settlements flank canals carrying the wastewater out of the city and use them as a disposal ground for untreated wastes. This renders the canals visibly polluted (Ramsar 2002) and raise concerns for the water that enters the ECW. Untreated industrial effluents find their way to the ECW which contaminate the wetland's water as well as the fish produced as part of a resource recovery system (Roy et al. 2011).

3.2. SALTWATER MARSHES

The saltwater marshes were situated at the lowest elevation of the city and drained the water to the Bay of Bengal through the river Kulti and then, Bidyadhari (Ghosh and Sen 1987). These rivers continued further east to another network of canals which aided navigation and was crucial to thriving trade and commerce in the region connecting Assam and parts of present-day Bangladesh (Inglis 1909). A substantial controversy surrounded these saltwater marshes, recognized as tidal wetlands, which cause the water accumulated into the wetlands from the city, to drain into the eastern canals and ultimately meet the Bay of Bengal in the south. These wetlands have always been understood as a nuisance owing to their swampy nature and standing water, which led to the breeding of mosquitoes, and have been considered for reclamation for other uses, since the early nineteenth century (Smith 1869). Although these wetlands were seen as the city's "limit of building-land" (Richards 1914, xiv), a letter from the Honorary Secretary of the Anglo-Indian Association to C H Bompas (then Chairman of the CIT) talked about expanding the city to the east by obliterating the saltwater lakes:

> *Their (the salt lakes') presence … is a perpetual menace to its (the city's) health and unreasonable restriction to its natural expansion. To recover these … and put them to profitable use should be made the aim of Government… It cannot possibly be a task beyond engineering skill when examples exist all over the world of vast areas … being rescued from swamps, and even from the sea, to be put under the plough after a few years.* T.A. Milne, Honorary Secretary, The Anglo-Indian Association, Calcutta (CIT 1913, 31). Source: British Library Archives of India Office Records.

The marshes to the east of Calcutta have been discussed repeatedly concerning miasmic diseases (Hamilton 1727; Martin 1837), and their role in the poor sanitary condition of the city (Smith 1869). Drainage has always been a problem for the city and its inhabitants, evident in increased mortality due to water-borne diseases (Clark 1855). There have been several attempts to solve the drainage problem, of which the canals were a crucial part, especially the seasonal flooding during the monsoon months. While the Circular canal in the north served as a military measure against the Maratha rulers, the Tolly's Nullah in the south provided a better connection to the River Hooghly for navigation purposes. However, the canals to the east of the city, including the Beliaghata Canal and the New Cut Canal have found special mention as conduits for the city's stormwater in the comprehensive documentation by W. A. Inglis in his book titled *The Canals and Flood Banks of Bengal* (1909). They hold special relevance to the ecology of the city, due to their connectivity and proximity to the Ramsar-recognized Wetlands and the Sundarbans (A UNESCO World Heritage Site - 1997) further south of the city.

After India's independence from the British rule, from 1962-67, a part of these saltwater marshes, now recognized as the East Calcutta Wetlands, was filled up to accommodate the growing population of Calcutta. The township that replaced these marshes was named Salt Lake City (H. Chattopadhyay 1990).

3.3. THE EAST CALCUTTA WETLANDS (ECW)

Salt marshes represent a complex structure of flora, fauna, and microbes, characterized by frequently changing salinity, level of water, and seasonal temperature variation. The stability of such marshes depends on two primary characteristics: 1) sediment deposition, and 2) submergence of marsh due to the inflow of saline water (Mitsch and Gosselink 2000). The saltwater marshes changed to freshwater lakes when the River Bidyadhari dried up in 1928 and stopped the inflow of saline water from the Bay of Bengal (Ghosh and Sen 1987, 222). The marshes used to harbor saltwater fisheries, which changed to sewage-fed fisheries in 1930, and the wastewater began to be carried away by the River Kulti (Ghosh and Sen 1987, 222). With a lower inflow of saline water and more inflow of freshwater from the city, the salinity of the wetlands decreased, making it possible

to cultivate paddy and vegetables (Mukherjee 2015). The wastewater from Calcutta now flows through the eastern canals into the ECW, where the sewage serves as nutrients for fish production and agricultural fields (Dey and Banerjee 2013). The ECW consists of a core region with fishponds, where wastewater is treated and fishing is practiced, garbage-farming region for seasonal vegetables using wastewater for irrigation, and a vast paddy farming region (Furedy and Ghosh 1984). Through its resource recovery system, using farming and aquaculture, the ECW also acts as a significant social contributor by providing food, sanitation, and livelihood.

3.3.1. PRESENT-DAY WATER WOES

The ECW comprises several small and large fishponds that are either registered with the government or privately owned. To understand the present issues of drainage and water resources management, we conducted interviews amongst government officials and institutions about the historical evolution of water management and the current dangers faced by these wetlands. We also interviewed 40 fishermen and owners from three of these fisheries, ages ranging from 24 to 60, to learn about the activities involved that make this a successful resource recovery system, and the factors which impact their sustenance and the quality of fish production. Open-ended interviews with these fishermen and officials in managing institutions revealed the following findings:

1. Fish production in the ECW is largely impacted due to transit corridor runoff and decreasing organic matter in the wastewater because of changing land use along the canals. Due to the lack of organic matter in the wastewater, many fisheries depend on artificial feed to keep up with the production and meet the demand for fish in the city. On the other hand, the canals flanked by small industries, commercial establishments, and leather tanneries have historically polluted the water carried away from the city.
2. The depth of the ponds has reduced at some places to less than two feet due to the inflow of silt through the canals, which deters the steady production of fish. Some of the government registered fisheries have been excavated to increase the depth, with the excavated earth used to increase the peripheral levee height. Most fisheries cannot afford to stop production for the duration of this crucial process of revival and therefore continue fishing with these limitations. The fisheries being the only source of income makes it difficult for resident workers to make ends meet daily.
3. Officials in government institutions in charge of addressing encroachment issues have shed light on factors affecting the function of this resource recovery system and complexities associated with underlying political and social processes, the discussion of which is beyond the scope of this paper. But we have noted these findings as crucial interactions between the resources and their users, providing insights on social and cultural capital, and their vitality in managing these ecological resources.

The lack of awareness and effort to improve canals and flanking land further complicates these problems, leading to a gap in simultaneous prioritization and integration of social and ecological processes. Connection with the ECW makes the assessment of drainage issues and the understanding of relevant hydrological systems and ecological functions more difficult, due to the lack of a comprehensive, integrated approach in addressing social and ecological aspects.

CONCLUSION

The East Calcutta Wetlands form a crucial part of the regional hydrological system, which includes the canals, the River Hooghly, as well as the city's connection to the Bay of Bengal in the Sundarbans deltaic region that hosts a large mangrove population and acts as a reserve for the endangered Royal Bengal Tiger (Chundawat, Khan, and Mallon 2011). As a resource recovery system, the wetlands use the city's wastewater for its diverse uses in sewage-fed fisheries and farmlands. This process, recognized by the Ramsar Convention for its uniqueness, takes place in the 12,500 hectares of wetlands, out of which fishponds cover about 4000 hectares. While the wetlands are not efficient in groundwater recharge, they are useful in trapping sediments and retaining nutrients through an aquatic food chain (Ramsar 2002). Many years ago, a concern was raised by David Cowie (1857) in the Drainage Report of Calcutta regarding whether the practice of converting sewage into deodorized manure would be accepted in India. The report also questioned whether this would, in the end, turn out to be profitable. Today, the ECW helps drain the city, treats its wastewater, and generates crucial resources for its inhabitants (Ghosh 2014).

This historical study of the city's human-water negotiations reflects the strenuous relationship between the place, its people, and governing institutions. In the waterscape of Calcutta and surrounding regions, spatial decisions on natural systems were based on social drivers, and the importance of water resources would yet be reflected in urban planning initiatives.

This trend continued in the post-colonial era, when a portion of the eastern wetlands draining the city's wastewater would be filled up and "reclaimed" for urban development. The practice of de-prioritizing water resources over real estate and "developmental" activities continues to threaten Calcutta's waterscape. Without a more involved strategy to better understand the social capital of ecological resources, urban development and water management will remain a dichotomy and stray further from the necessary integration of social and ecological systems, which is the need of the hour.

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ENDNOTES

1 The name "Calcutta" was changed to "Kolkata" in 2001 (Datta 2012). The swamps towards the east of the city mentioned in Richards's Report (Richards 1914) were later recognized by the Ramsar Convention as the "East Calcutta Wetlands." We use the name Calcutta throughout this paper for consistency.

2 Examples of such reports include *Certain Matters Connected to the Sanitation of the Town of Calcutta* (Beverley and Lidderdale 1885), *A Report on the Drainage of Calcutta* (Clark 1855), and *Report of the Committee on the Drainage of Calcutta* (Cowie 1857), and *Report, by Request of the Trust, on the Condition, Improvement and Town Planning of the City of Calcutta and Contiguous Areas* (Richards 1914).

3 A. J. Apjohn, then Chief Engineer for the Calcutta Port Trust and Fellow and Faculty of Engineering at the University of Calcutta delivered *Two lectures on Navigation Canals in India* at the Sibpur Civil Engineering College (now known as the Indian Institute of Engineering, Science and Technology, Shibpur) on 27th March and 9th April 1895. Here, he built on several experiments conducted on the River Hooghly, the Orissa Coast Canal, the Tolly Nullah and the River Bhageratti to understand the nature of the waterways in this region and propose design solutions such as sluices, lock gates and silt traps, to make them navigable (Apjohn 1895).

4 The word "Nullah" was derived from a local Bengali word which meant water channels (Yule and Burnell 1886).

REFERENCES

Agnihotri, Indu. 1996. "Ecology, Land Use and Colonisation: The Canal Colonies of Punjab." *The Indian Economic & Social History Review* 33, no. 1: 37-58.

Apjohn, J. H. 1895. *Navigation Canals in India.* Calcutta: Bengal Secretariat Press.

Bakker, Karen. 2012. "Water: Political, Biopolitical, Material." *Social Studies of Science* 42, no. 4: 616-23.

Beverley, H., and R. Lidderdale. 1885. *Certain Matters Connected to the Sanitation of the Town of Calcutta.* Calcutta: Bengal Secretariat Press

Bhattacharjee, Chandrani. 2014. "Canals and its relevance to the Kolkata Megacity." *Abhinav National Monthly Refereed Journal of Research in Arts & Education* 3 (5): 20-24.

Biswas, K. R. 2001. *Rivers of Bengal: A Compilation*. Calcutta: West Bengal District Gazetteers, Higher Education Department, Government of West Bengal.

Bompas, C. H. 1927. "The Work of The Calcutta Improvement Trust." *Journal of the Royal Society of Arts* 75 (3868): 199–219.

Chattopadhyay, H. 1990. *From Marsh to Township East of Calcutta: A Tale of Salt Water Lake and Salt Lake.* Calcutta: KP Bagchi.

Chattopadhyay, Swati. 2000. "Blurring Boundaries: The Limits of 'White Town' in Colonial Calcutta," *Journal of the Society of Architectural Historians*, 59(2), pp.154-179.

Chaudhuri, Sukanta. 1990. *Calcutta, the Living City (Vol. 1 & 2)*. New York;Calcutta; Oxford University Press.

Chundawat, R. S., J.A. Khan, and D.P Mallon. 2011. "Panthera Tigris Ssp . Tigris , Bengal Tiger." *The IUCN Red List of Threatened Species 2011*: 8235. https://doi.org/T136899A4348945.

CIT. 1913. *Annual Report on the Operations of the Calcutta Improvement Trust for the Year 1912-1913.* Calcutta: Calcutta Improvement Trust.

Clark, W. 1855. *A Report on the Drainage of Calcutta.* Calcutta: Edmund D'Cruz and Co.

Cotton, H. E. A. 1907. *Calcutta Old and New. Calcutta: W. Newman & Co*.

CCowie, David. 1857. *Report of the Committee on the Drainage of Calcutta*. Calcutta: "Calcutta Gazette" Office.

D'Souza, Rohan. 2006. "Water in British India: The Making of a 'Colonial Hydrology.'" *History Compass* 4, no. 4: 621-628. https://doi.org/10.1111/j.1478-0542.2006.00336.x.

Datta, Partho. 2012. *Planning the City: Urbanization and Reform in Calcutta, c. 1800 - c. 1940*. New Delhi: Tulika Books.

Dey, Debanjana, and Sarmila Banerjee. 2013. "Ecosystem and Livelihood Support: The Story of East Kolkata Wetlands." *Environment and Urbanization Asia* 4, no. 2: 325-337. https://doi.org/10.1177/0975425313511158.

Fryer, John. 1861. "1698. A New Account of East-India and Persia." *Eight Letters. Being Nine Years Travels, Begun 1672. And Finished* 1681.

Furedy, Christine, and Dhrubajyoti Ghosh. 1984. "Resource-Conserving Traditions and Waste Disposal: The Garbage Farms and Sewage-Fed Fisheries of Calcutta." *Conservation and Recycling* 7 no. 2-4: 159-165. https://doi.org/10.1016/0361-3658(84)90014-6.

Ghosh, Dhrubajyoti. 2014. *Ecosystem Management: Towards Merging Theory and Practice*. New Delhi: Nimby Books.

Ghosh, Dhrubajyoti, and Susmita Sen. 1987. "Ecological History of Calcutta's Wetland Conversion." *Environmental Conservation* 14, no. 3: 219-226. https://doi.org/10.1017/S0376892900016416.

Gilmartin, David. 1994. "Scientific Empire and Imperial Science: Colonialism and Irrigation Technology in the Indus Basin." *The Journal of Asian Studies* 53, no. 4: 1127-49.

Hamilton, Alexander. 1727. *A New Account of the East Indies (Vol. 1 & 2)*. Edinburgh: John Mosman.

Home, Robert. 2016. "British Colonial Civic Improvement in the Early Twentieth Century: E. P. Richards in Madras, Calcutta, and Singapore." *Planning Perspectives* 3, no. 4: 635-644. https://doi.org/10.1080/02665433.2016.1185961.

Hornsby, Stephen J. 1997. "Discovering the Mercantile City in South Asia: The Example of Early Nineteenth-Century Calcutta." *Journal of Historical Geography* 23, no. 2: 135-50.

Inglis, W. A. 1909. *The Canals and Flood Banks of Bengal*. Calcutta: Bengal Secretariat Press.

Kundu, A. K., and P. Nag. 1990. *Atlas of the City of Calcutta and Its Environs*. National Atlas & Thematic Mapping Organisation, Ministry of Science and Technology, Government of India.

Martin, Sir James Ranald. 1837. *Notes on the Medical Topography of Calcutta*. GH Huttmann, Bengal Military Orphan Press.

Mitsch, W J, and J G Gosselink. 2000. *Wetlands (3rd Edn)*. *Wetlands. New York: Wiley.*

Mukherjee, Jenia. 2015. "Beyond the Urban: Rethinking Urban Ecology Using Kolkata as a Case Study." *International Journal of Urban Sustainable Development* 7, no. 2: 131-146. https://doi.org/10.1080/19463138.2015.1011160.

Nair, P. Thankappan. 1986. *Calcutta in the 17th Century*. Calcutta: Firma KLM.

Ramsar. 2002. "Information Sheet on Ramsar Wetlands (RIS)." *Ramsar Convention.* https://rsis.ramsar.org/RISapp/files/RISrep/IN1208RIS.pdf

Richards, E P. 1914. *Report, by Request of the Trust, on the Condition, Improvement and Town Planning of the City of Calcutta and Contiguous Areas*. Hertfordshire: Jennings & Bewley.

Roy, Utpal Singha, Buddhadeb Chattopadhyay, Siddhartha Datta, and Subhra Kumar Mukhopadhyay. 2011. "Metallothionein as a Biomarker to Assess the Effects of Pollution on Indian Major Carp Species from Wastewater-Fed Fishponds of East Calcutta Wetlands (a Ramsar Site)." *Environmental Research, Engineering and Management* 58, no. 4: 10-17.

Sen, Ranjit. 2000. *A Stagnating City: Calcutta in the Eighteenth Century*. Calcutta: Institute of Historical Studies.

Smith, David Boyes. 1869. *Report on the Drainage and Conservancy of Calcutta*. Calcutta: Bengal Secretariat Press.

Sreemani, Soumitra. 1998. "Problems of Writing a History of Calcutta of the late 18th Century." In *Proceedings of the Indian History Congress* 59: 579-86.

Stone, Ian. 2002. *Canal Irrigation in British India: Perspectives on Technological Change in a Peasant Economy*. Vol. 29. Cambridge: Cambridge University Press.

Tan, Tai-Yong Yong. 2007. "Port Cities and Hinterlands: A Comparative Study of Singapore and Calcutta." *Political Geography* 26, no. 7: 851-65. https://doi.org/10.1016/j.polgeo.2007.06.008.

Times of India (OUR, O.C.). 1929. *Calcutta Improvement Trust: How the City Has Changed the Progress of a Tremendous Task*. Mumbari: Times of India.

Whitcombe, Elizabeth. 1972. *Agrarian Conditions in Northern India*. Berkeley: University of California Press.

Yule, H., and A. C. Burnell. 1886. *Hobson-Jobson: Being a Glossary of Anglo-Indian Colloquial Words and Phrases, and of Kindred Terms: Etymological, Historical, Geographical, and Discursive*. London: J. Murray.